ONCOLITE FORMATION AND PALEOECOLOGY OF THE FLAGSTAFF LIMESTONE AND NORTH HORN FORMATION, SOUTH GUNNISON PLATEAU, WEST OF MANTI, UTAH

Senior Thesis

Presented in Partial Fulfillment of the Requirements for the Degree Bachelor of Science

by

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Oncolite formation and paleoecology in the Flagstaff Limestone and North Horn Formation, South Gunnison Plateau, West of Manti, Utah.

Introduction

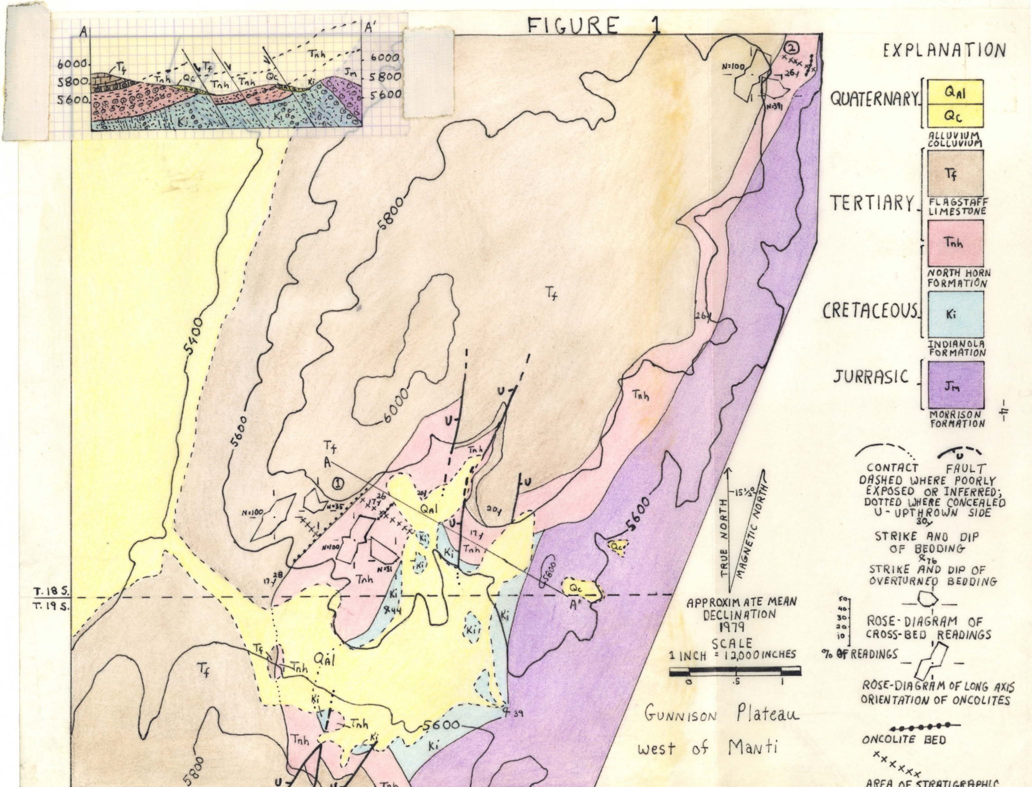
Oncolites of several varieties have been recognized and identified in the lacustrine Flagstaff Limestone and fluvial North Horn Formation of Central Utah (Weiss, 1969; Birsa, 1973; Stanley and Collinson, 1979). The oncolites of the southern region of the Gunnison Plateau (Fig. 1) are excellent for the study of microstructure and also are useful in the understanding of the paleoecology and the paleoenvironmental setting of some Flagstaff and North Horn carbonates. The oncolitic limestones described by Weiss (1969) contain specimens which are predominantly of the mode SS-C which are interpreted by Logan et al. (1964), to form under water and in a high energy environment.

Geologic Setting

The geology of the Wasatch Plateau-Gunnison Plateau portion of central Utah was first described by Spieker (1930, p. 55-56), who described the area as representing part of the Cretaceous Rocky Mountain geosyncline, and the transition area between the Colorado Plateau and the Basin and Range structural provinces. The major structure recognized within the depositional basin containing the Lower Tertiary Flagstaff Limestone and coeval rocks of the North Horn Formation of central Utah have been described by Spieker (1946, 1949) and Gilliland (1963). These major structures can be summarized as being the (1) Canyon Range, Pavant Range, and Mount Nebo thrust faults of Upper Cretaceous age that are along the eastern margin of the Sevier orogenic belt; (2) anticlines and synclines of upper Cretaceous and lower Tertiary age that are east of, and parallel with, the thrust belt; and (3) Tertiary monoclines and Basin and Range normal faults superimposed on the Cretaceous and lower Tertiary structures (Stanley and Collinson, 1979).

Facies patterns in the Flagstaff Limestone and paleocurrent directions have shown the basin to have been filled by a progradation from the east to the west (Stanley and Collinson, 1979). Locally in the southern Gunnison Plateau, the Sanpete Valley anticline to the east exerted the most influence upon the North Horn sedimentation while regionally the Sevier thrust belt to the west was the most important factor (Godo, 1979; Vorce, 1979).

FIGURE 1


A
A'
6000
5800
5600
Tf
Tnh
Qc
Ki
Jm
EXPLANATION
QUATERNARY
Qal
Qc
ALLUVIUM
COLLUVIUM
TERTIARY
Tf
FLAGSTAFF LIMESTONE
Tnh
NORTH HORN FORMATION
CRETACEOUS
Ki
INDIANOLA FORMATION
JURRASIC
Jm
MORRISON FORMATION
CONTACT
FAULT
DASHED WHERE POORLY EXPOSED OR INFERRED; DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
STRIKE AND DIP OF BEDDING
STRIKE AND DIP OF OVERTURNED BEDDING
ROSE-DIAGRAM OF CROSS-BED READINGS
% OF READINGS
ROSE-DIAGRAM OF LONG AXIS ORIENTATION OF ONCOLITES
ONCOLITE BED
AREA OF STRATIGRAPHIC SECTION
TRUE NORTH
MAGNETIC NORTH
15½°
APPROXIMATE MEAN DECLINATION
1979
SCALE
1 INCH = 12,000 INCHES
0
.5
1
T. 18 S.
T. 19 S.
5400
5600
5800
6000
N=100
N=35
N=31
N=391
Gunnison Plateau
west of Manti

-4-

Oncolite Horizons

Many oncolites of this region have been described by Weiss (1969). These are mainly subellipsoidal, subspherical or subconical in shape. Pebble sizes were observed in both formations (Sections 1 and 2 of Figure 2), but with cobble sizes predominating in the North Horn. Weiss (1969) observed the largest specimens in the Flagstaff to be 9 cm. in diameter, while the largest in the North Horn was 150 cm. in diameter and was found to be compound as were most specimens over 50 cm. in size. My observations of Flagstaff oncolites found the largest to be 32 cm. in diameter, while the largest specimen in the North Horn was found to be 20 cm. in diameter (Appendix I).

The first occurrence of oncolites in Section 1 is in the middle of the North Horn Formation overlying pebble size conglomerates. The lower portion of the North Horn is composed of cross-bedded calcareous sandstone and interbedded siltstone and mudstone. The oncolites are in a lithic arenite (Fig. 3) according to the classification of Pettijohn, Potter and Siever (1973, p. 158). Overlying the oncolites is cross-bedded sandstone which grades upward into interbedded calcareous sandstone and mudstone. The upper North Horn Formation is composed of a thick slope-forming sequence of interbedded mudstone and siltstone.

The base of the Flagstaff in Section I is marked by massive oncolitic limestone (Figs. 4, 5) which is laterally discontinuous, whereas the base of the Flatgstaff in Section 2 is marked by a micritic limestone. Two more oncolitic units overlie the basal unit of the Flagstaff in Section I and are interbedded with a cross-bedded calcerenite. Overlying these you find fossiliferous and micritic limestone.

In Section 2 (Fig. 2), five oncolitic units were noted in the North Horn Formation. These are interbedded with mudstone and cross-bedded sandstone (Figs. 6, 7). From the upper oncolite unit in the North Horn to the base of the Flagstaff is a thick sequence of slope forming interbedded mudstone and sandstone. The base of the North Horn is separated by an angular unconformity in Section 2 with the Cretaceous Indianola Group, and in Section 2 the unconformity is with the Jurassic Morrison Formation.

The North Horn and Flagstaff rocks shown in Figure I are on the western flank of the Sanpete Valley anticline, and stratigraphic portions of the rock reflect the complex intertonguing of fluvial and lacustrine rocks formed along the margin of the topographic high produced in the Lake Flagstaff by the Sanpete Valley anticline.

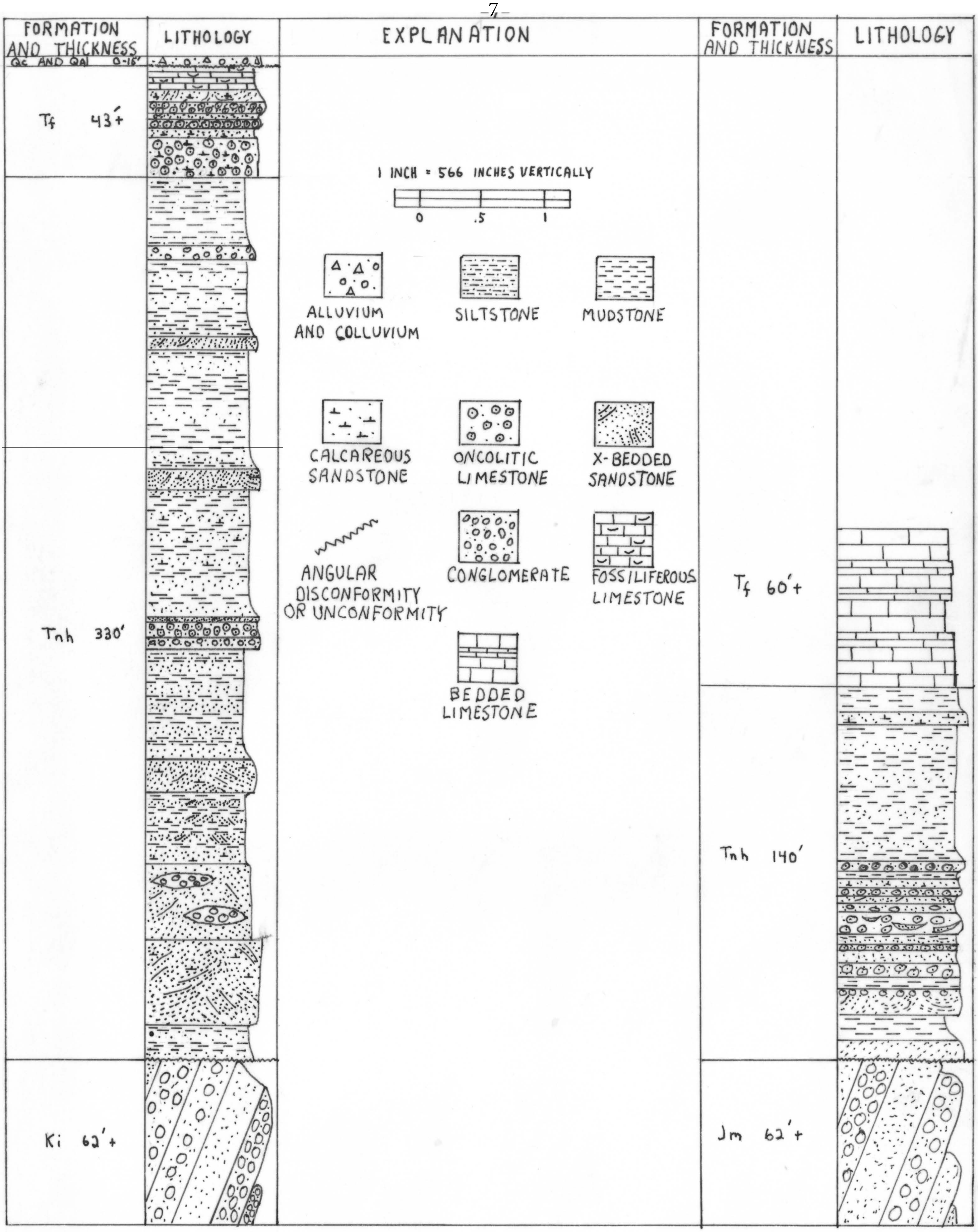

FORMATION AND THICKNESS
LITHOLOGY
EXPLANATION
FORMATION AND THICKNESS
LITHOLOGY
Qc AND Qal 0-15'
Tf 43'+
Tnh 330'
Ki 62'+
1 INCH = 566 INCHES VERTICALLY
0
.5
1
ALLUVIUM AND COLLUVIUM
SILTSTONE
MUDSTONE
CALCAREOUS SANDSTONE
ONCOLITIC LIMESTONE
X-BEDDED SANDSTONE
ANGULAR DISCONFORMITY OR UNCONFORMITY
CONGLOMERATE
FOSSILIFEROUS LIMESTONE
BEDDED LIMESTONE
Tf 60'+
Tnh 140'
Jm 62'+
SECTION 1
SECTION 2

FIGURE 2

3a

Figure 3a. Oncolites in a lithic arenite overlayed by cross-bedded sandstone and non-resistant mudstone. Section I, North Horn Formation

3b

3c

Figure 3b and c. Oncolitic conglomerate.
Section I, North Horn Formation.

4

Figure 4. Massive oncolitic limestone. Section I , base of Flagstaff.

5a

5b

Figure 5. a) Weathered surface of oncolitic limestone,
b) Polished surface from the same unit. Section I, base of Flagstaff.

6a

6B

Figure 6. a) Oncolites with cross-bedded sandstone,
b) Oncolites in lithic arenite. Section 2,
North Horn Formation.

7

Figure 7. Oncolites in lithic arenite, x-bedded sandstone on top, Gunnison Reservoir and Wasatch Plateau are to the north-east. Section 2, North Horn Formation.

Oncolite Sedimentology

In order to understand the basic sedimentology, over 100 paleocurrent measurements were taken in Sections I and 2 (Appendix 2). Three hundred measurements of oncolite long axes were also made in order to understand their preferred elongation in the oncolitic units (Appendix 3). Results of both measurements were incorporated into rose diagrams (Fig. I). The paleocurrent readings are normal to the long axes measurements. Rust (1972a, 1972b) observed the same phenomena while measuring the long axis orientation of pebbles in fluvial sediments. The oncolites long axes orientations in turn trend parallel (Fig. I) to the northeast-southwest axes of the Sanpete Valley anticlinal high (Stanley and Collinson, 1979).

Fluvial formation of oncolites has been documented in recent environments (Schafer and Stapf, 1978). Formation of these oncolites occurred at the outlet of the Rhine into Lake Constance. The presence of North Horn lakes has been suggested by Weiss (1969) and Stanley and Collinson (1979). The five oncolitic units in Section 2 of the north Horn Formation could be representative of a fluctuating shoreline with oncolites forming in the outlet to a North Horn lake.

The calcareous sandstone and oncolites of the Flagstaff in Section I can be interpreted as a nearshore lacustrine environment. Weiss (1969) concluded that the oncolites of the Flagstaff Limestone and North Horn Formation formed in agitated water less than 4 m. deep.

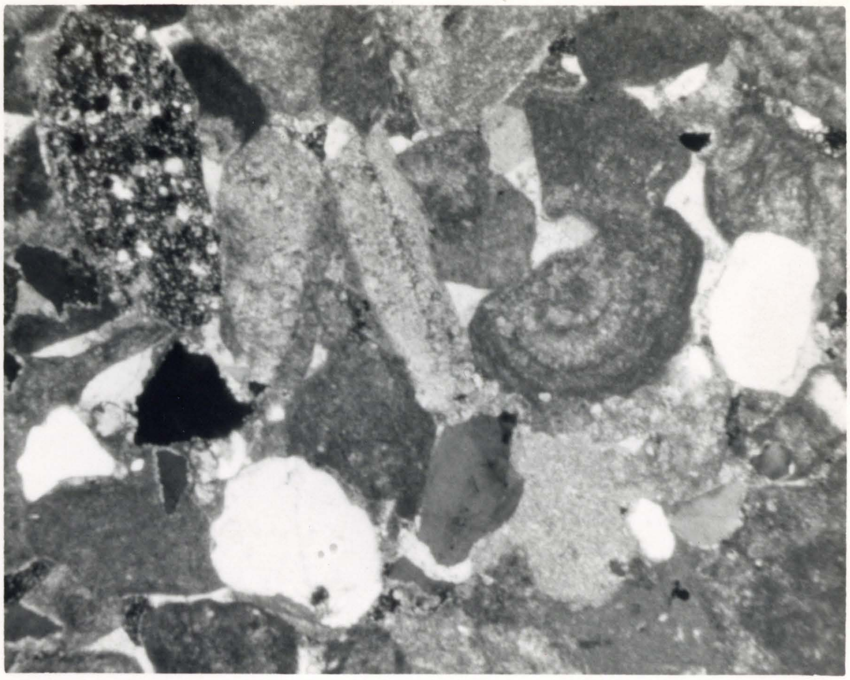
Microscopic Features

The calcareous sands of the Flagstaff contain a high percentage of oncolite and shell fragments with decreasing amounts of quartz, chert and chalcedony in a micritic matrix (Fig. 8). Molluscan fragments are often hard to identify, but all are pelecypods and gastropods. Weiss (1969) was able to relate many shells from the calcarenite and center nodules of oncolites of the region to species. The oncolite fragments contain up to 4 or 5 laminations and range in size from .1 mm. to 1.8 mm. The calcarenite is poorly to moderately-sorted, with a micritic matrix (Figs. 9, 10). Moderately sorted calcarenite shows evidence of algal mat fabric (Fig. 11) of mode LLH-C (Logan, et al., 1969) between quartz layers.

Examples of calcite encrusted charaphytes have been described in recent lacustrine environments (Lucci, 1974). Structures in the Flagstaff calcareous sandstone (Figs. 9, 10 and 12-14) possibly could be interpreted as being encrusted charaphyte stems which were later replaced by sparry calcite. Evidence of charaphytes also can be found in the center nodules of many Flagstaff oncolites (Figs. 15-19). Logan, et. al. (1969), Weiss (1969), Link, et. al (1978), and Schafer, et. al (1978) have all suggested algal participation in the growth of oncolites. Evidence of this algal participation was found using a scanning electron microscope on an etched Flagstaff oncolite broken parallel to the laminae (Fig. 20). North Horn oncolites contain molds that could be algal in origin (Fig. 21).

X-ray diffraction analyses of the laminae of both North Horn and Flagstaff oncolites (Appendix 4) are predominantly calcite with lesser amounts of quartz and dolomite. Calcite crystals in the light laminae of Flagstaff oncolites often show orientations perpendicular to the darker laminae (Fig. 23).

Additional microscopic features worth noting in the North Horn sandstones are the presence of lithic fragments (Figs. 23, 24) of limestone, argillaceous micrite, polycrystalline quartz and decreasing amounts of chert, chalcedony and feldspar (Fig. 25). Some micritic clasts (Fig. 26) contain evidence of possible cutanic features. Other micritic clasts contain laminated micritic coatings (Fig. 27). Large amounts of micrite and quartz grains with syntaxial rims (Fig. 28) inherited from Paleozoic sandstone sources are common throughout the oncolitic units. Sparitization of vugs formed in oncolitic nodules and between individual lamina was observed in both thin section (Fig. 29) and polished sections (Appendix 1).



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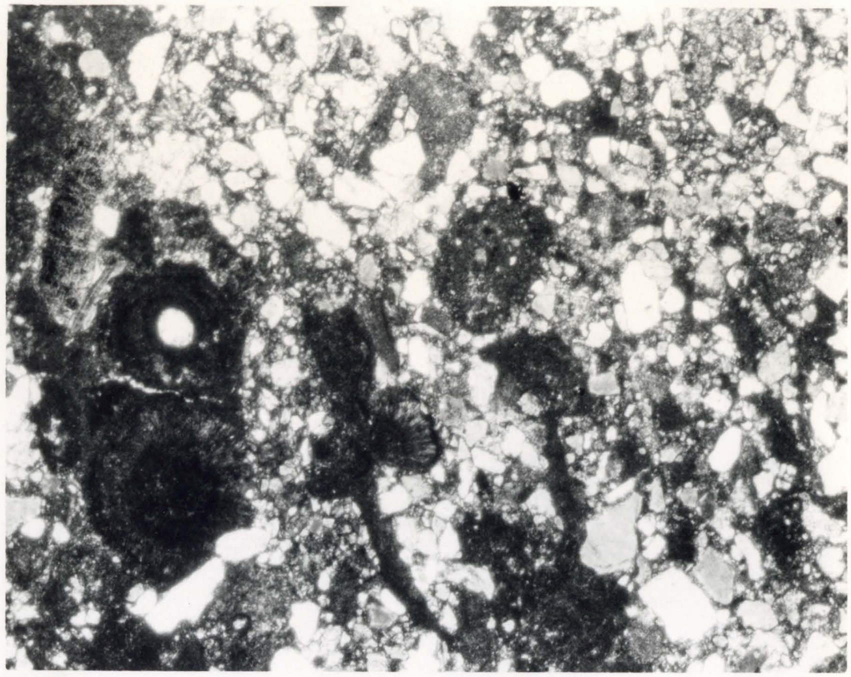
1mm

Figure 8. Photomicrograph of oncolite and shell fragments with decreasing amounts of quartz, chert and chalcedony in micritic matrix. Section I, Flagstaff Limestone.



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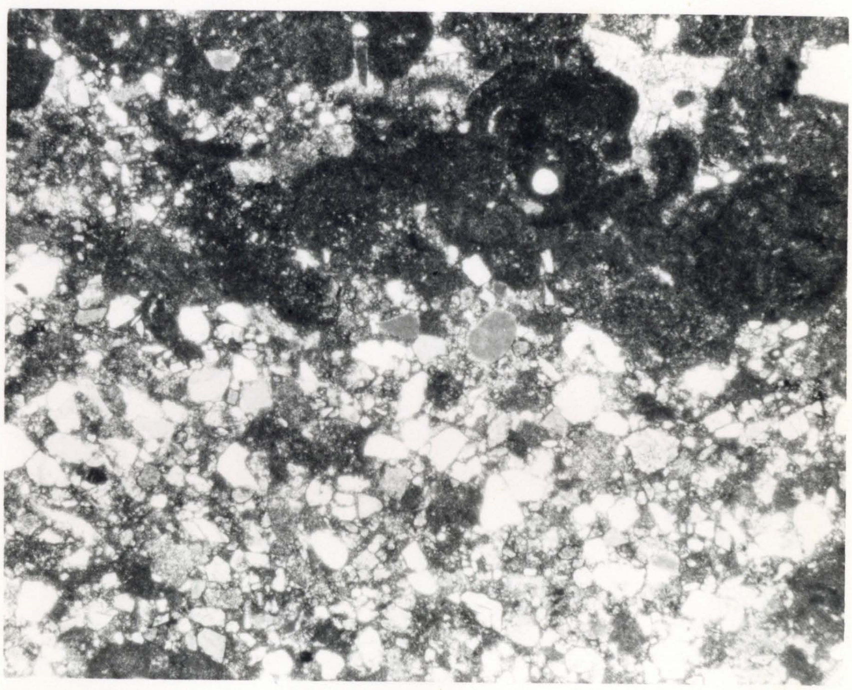

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Figures 9, 10. Photomicrographs of poorly-sorted calcarenite with micritic matrix. Nodules of sparry calcite with micritic coating. Section I, Flagstaff Limestone.

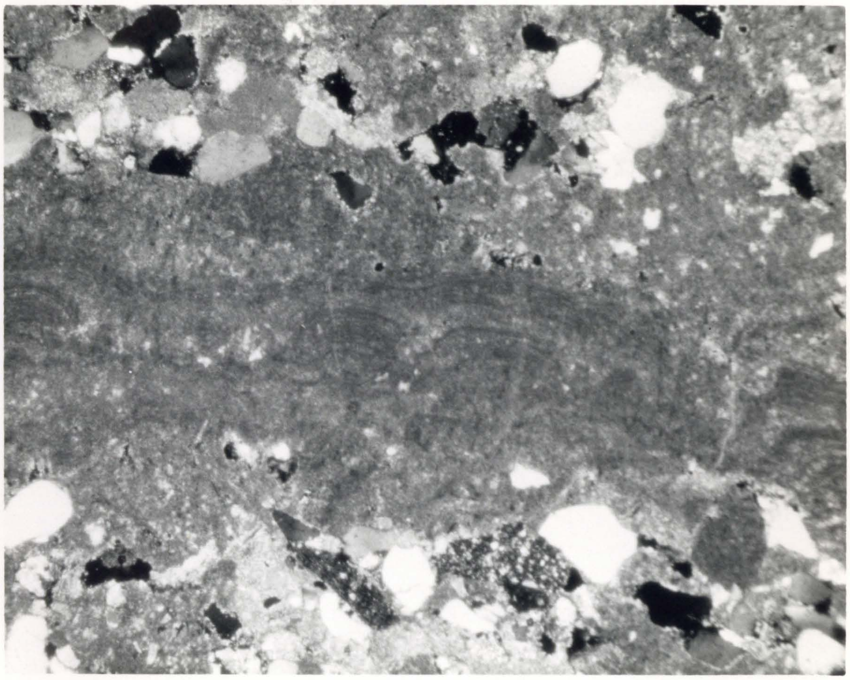

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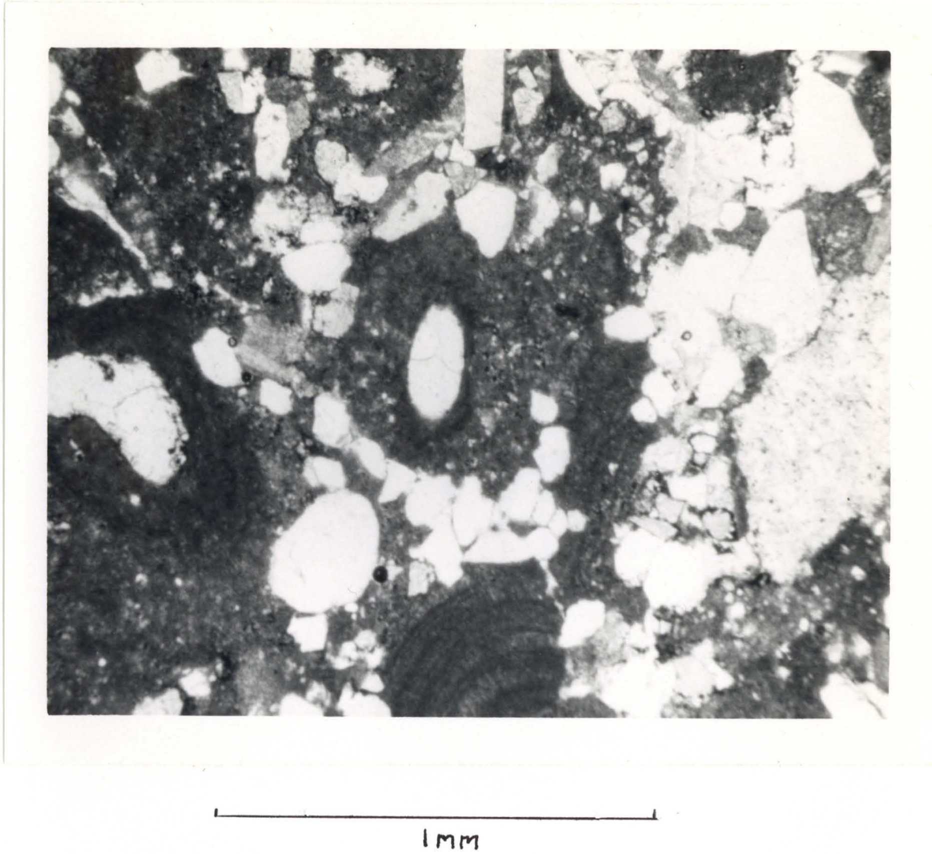
Figure 11. Photomicrograph of evidence of algal mat fabric in moderately-sorted calcareous sandstone. Section 1, Flagstaff Limestone.



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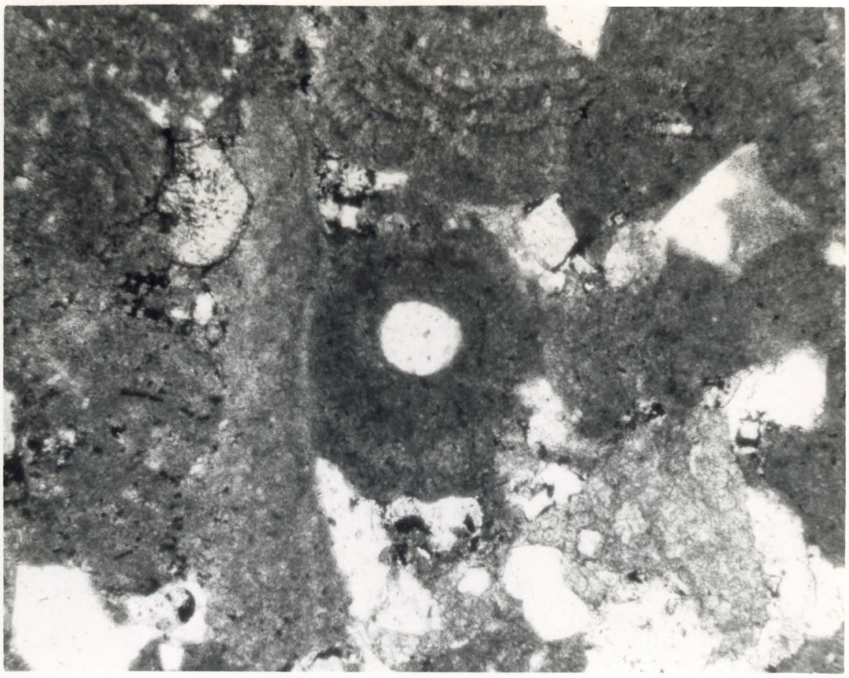
Figures 12-14. Photomicrographs of encrusted charaphyte stems which were later replaced by sparry calcite. Section 1, Flagstaff Limestone.



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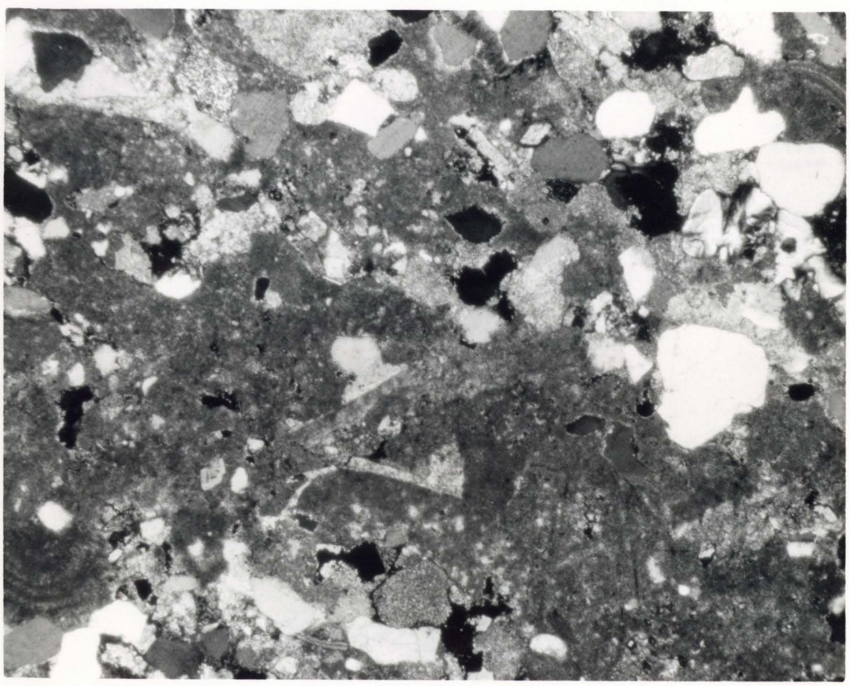

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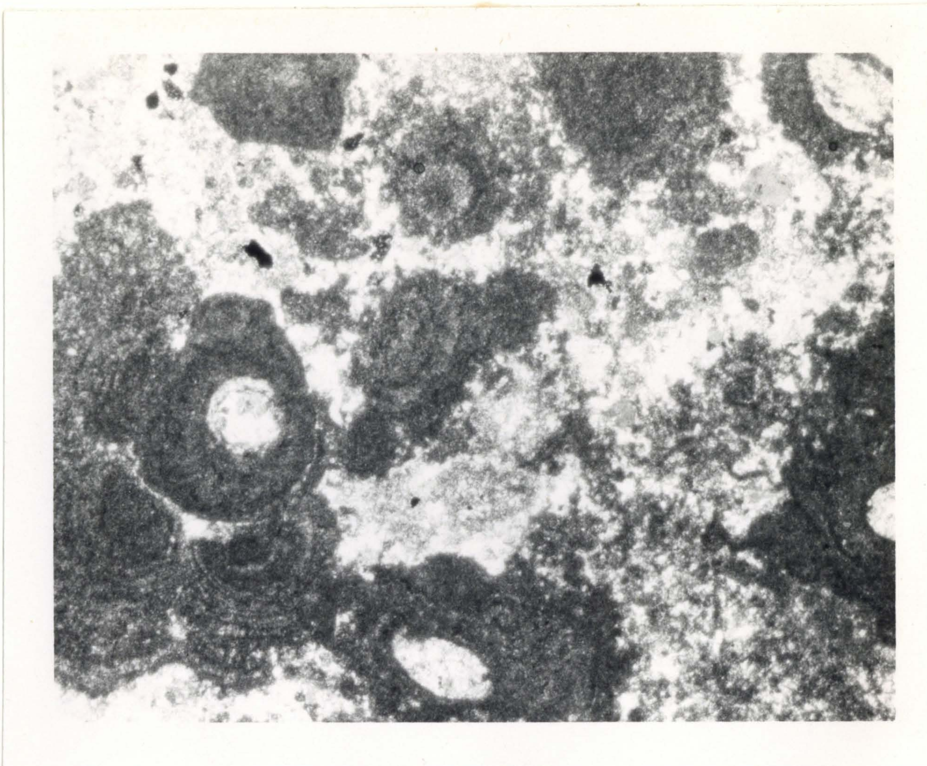

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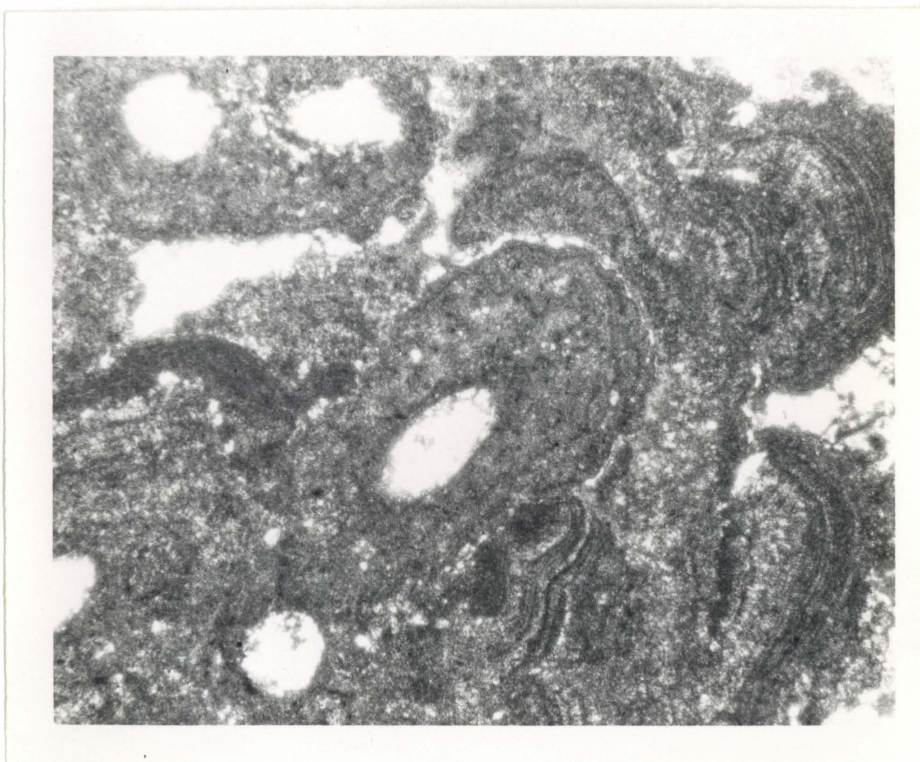
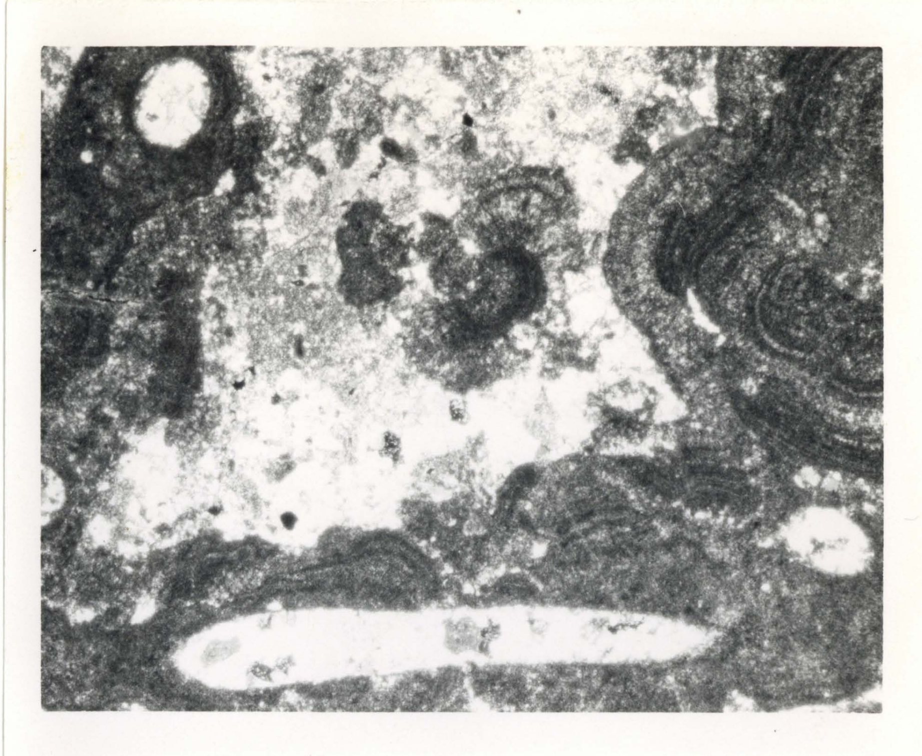
Figures 15-19. Photomicrographs of oncolite centers of encrusted charaphyte stems which were later replaced by sparry calcite. Section I, Flagstaff Limestone.

I6

1mm



I7



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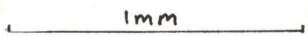

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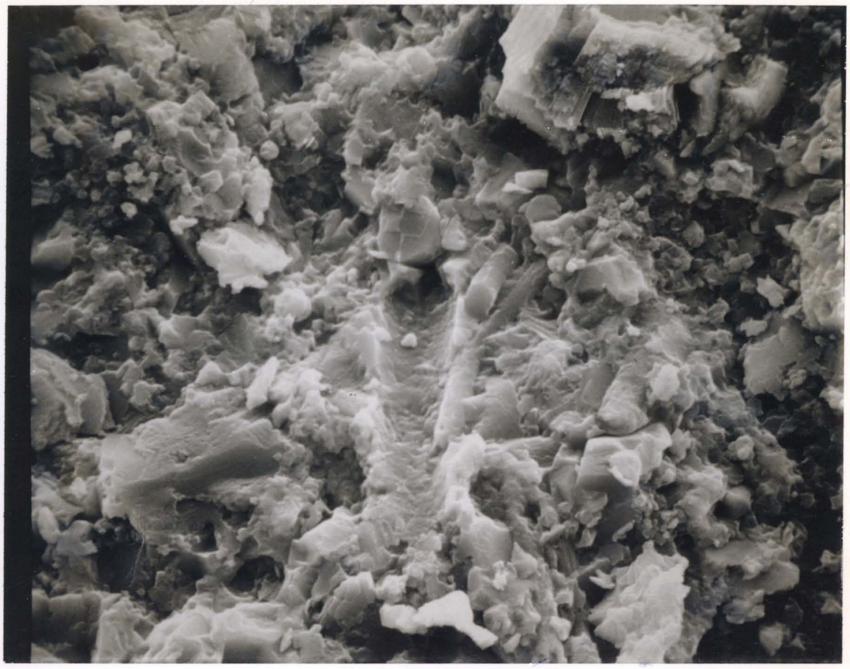
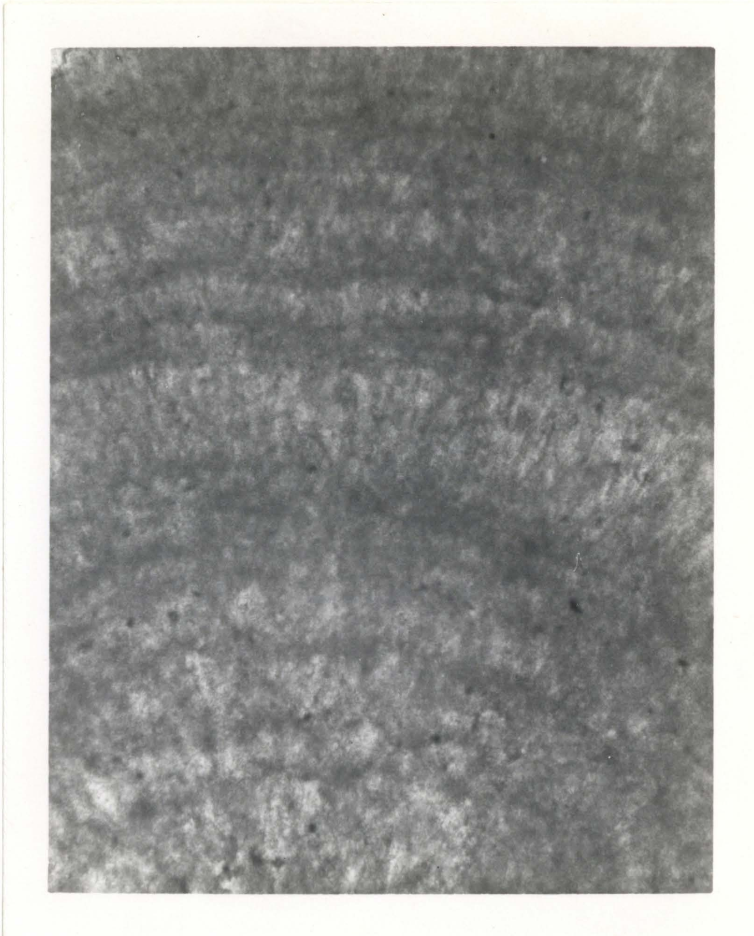
Figure 20. SEM view using the Cambridge S4-10 showing possible algal filaments that have been replaced by calcite. The lower Flagstaff oncolite was etched 10 seconds in 1/4 N. nitric acid. 1 cm. = .6 m.



21

Figure 21. SEM view of mold in an unetched North Horn oncolite. 1 cm. = 5m.



.5mm

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Figure 22. Photomicrograph of calcite crystals showing orientations perpendicular to darker laminae. Section I. Flagstaff Limestone.

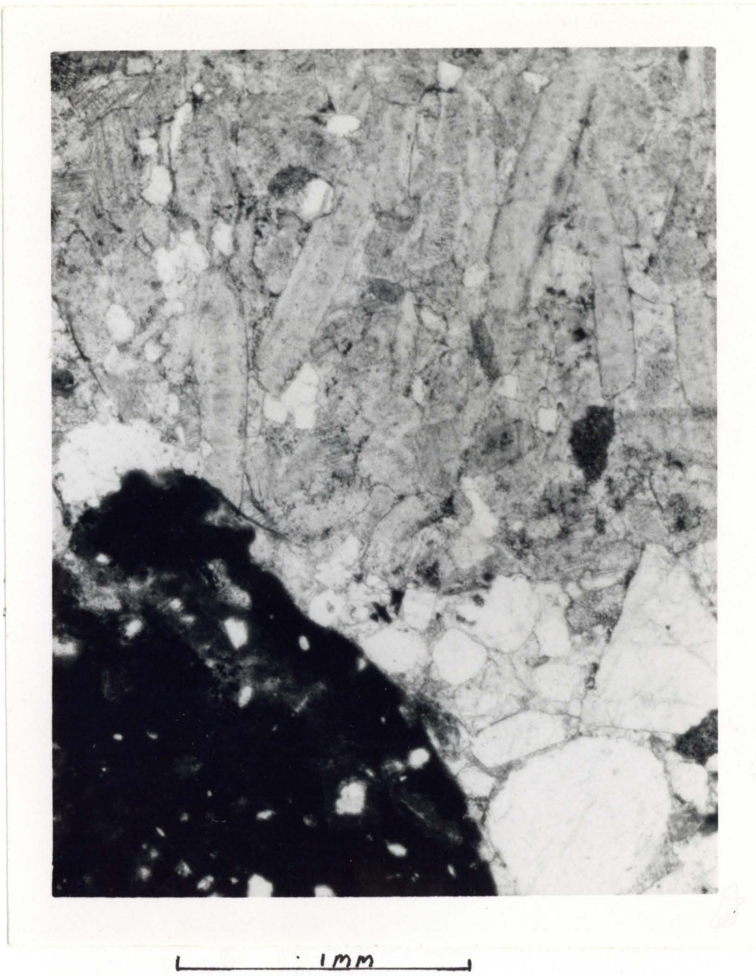

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Figure 23. Lithic fragments of fossiliferous limestone and argillaceous micrite. Section I. North Horn Formation.

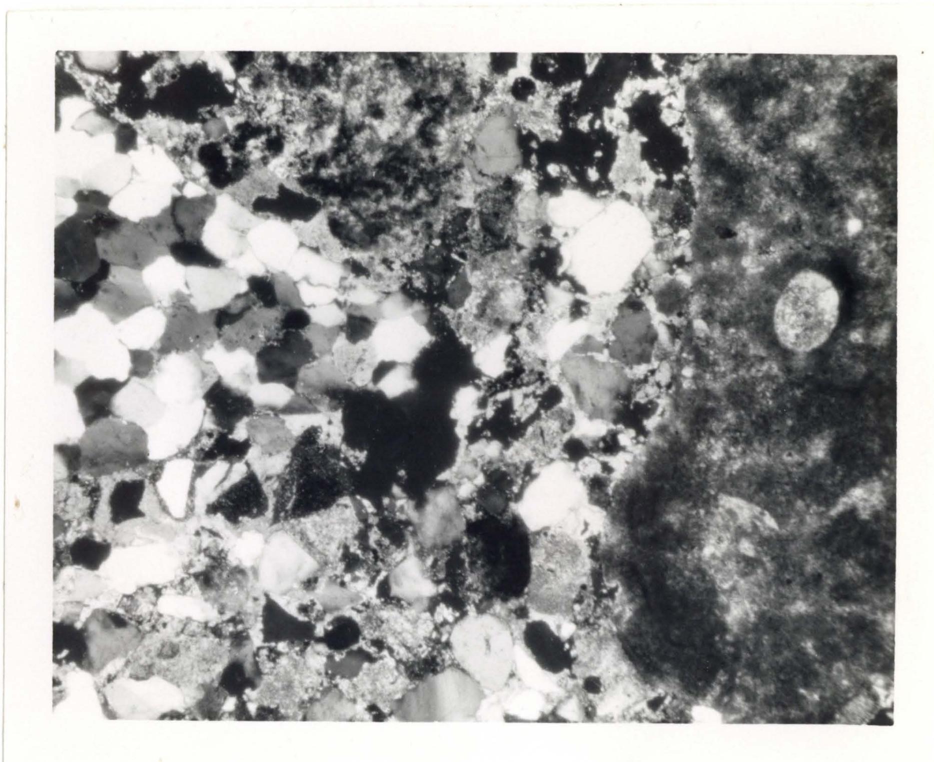

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Figure 24. Lithic fragments of polycrystalline quartz and micrite containing possible charaphyte stem. Section I, North Horn Formation.

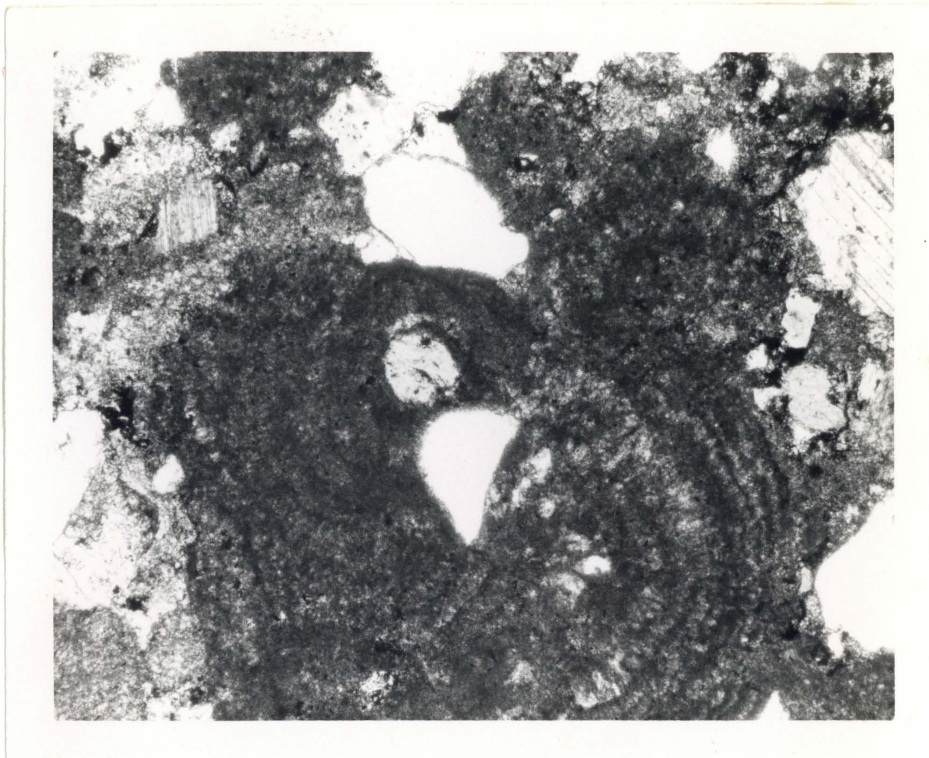

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Figure 25. Photomicrograph of feldspar and oncolite fragments. Evidence of micritic encrustment of replaced charaphyte stems. Section I, North Horn Formation.

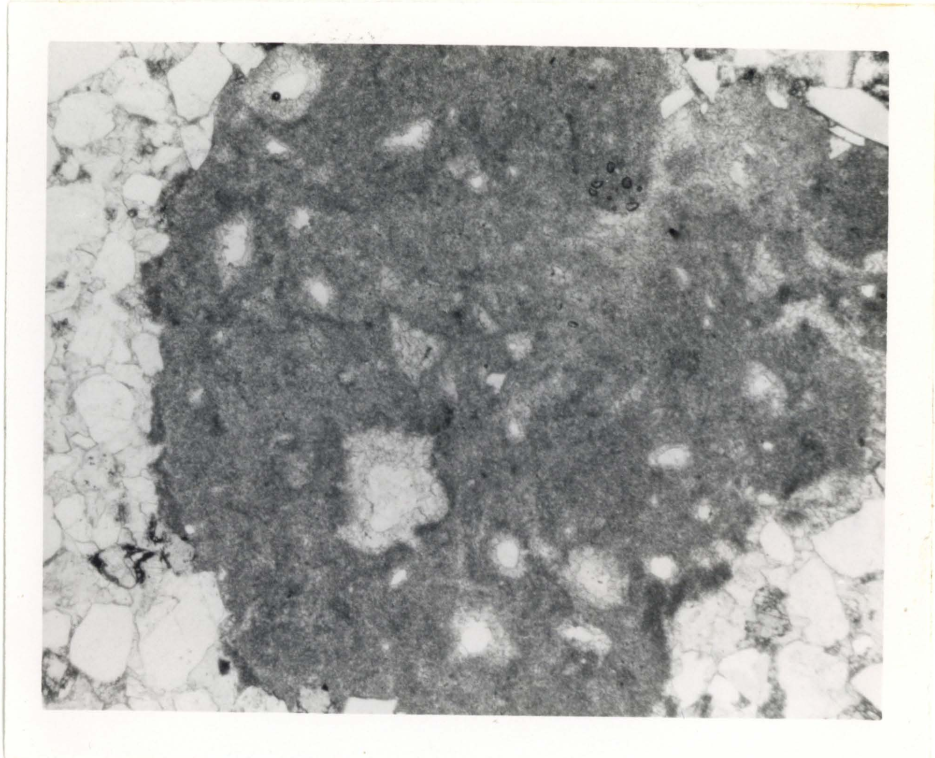

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Figure 26. Photomicrograph of micritic clast that exhibits cutanic (?) features. Section 2, North Horn Formation.

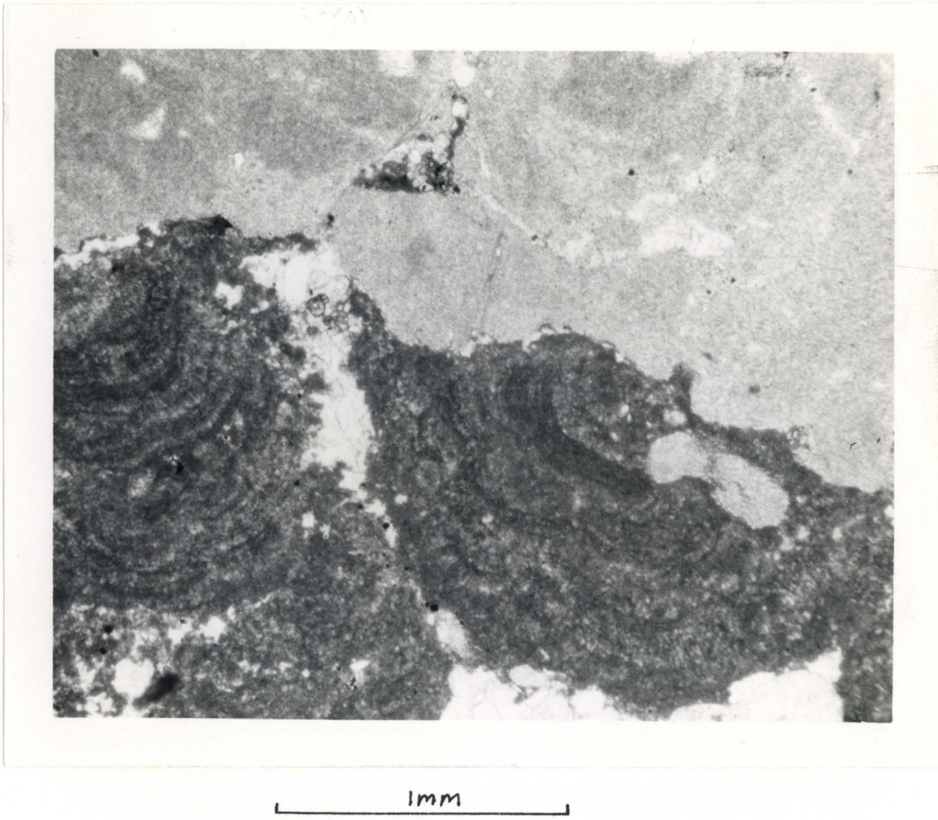

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Figure 27. Photomicrograph of micrite clast with laminated coating. Section 2, North Horn Formation.

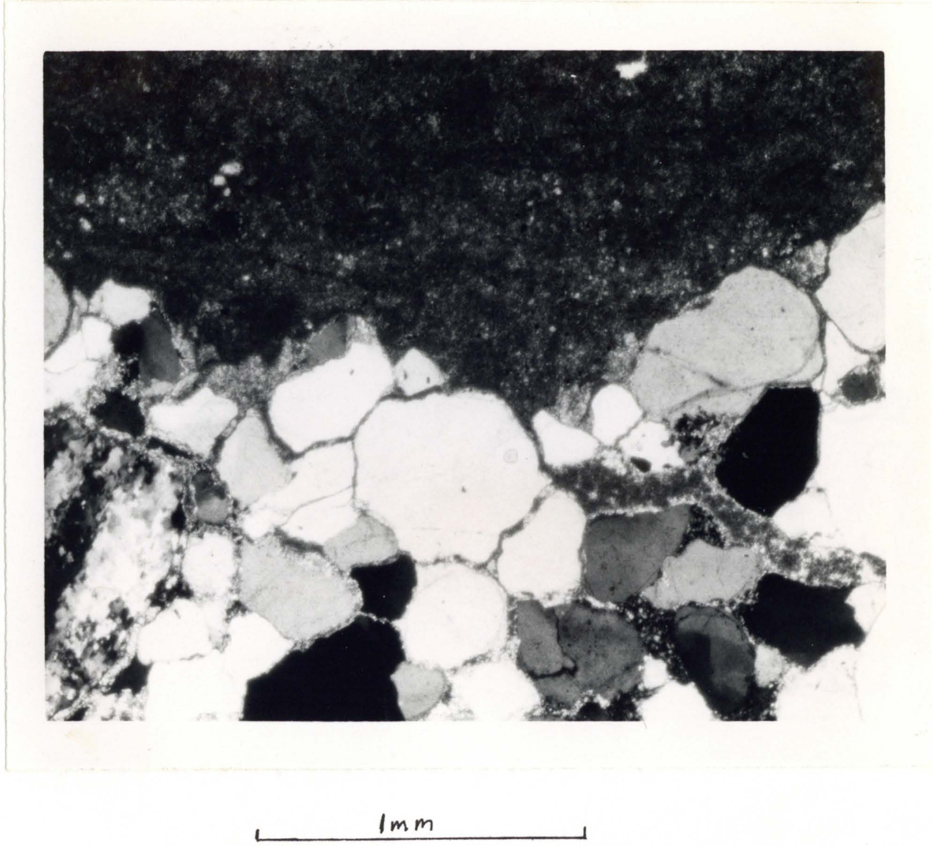

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Figure 28. Photomicrograph of micrite and quartz with syntaxial rims. Section 2, North Horn Formation.

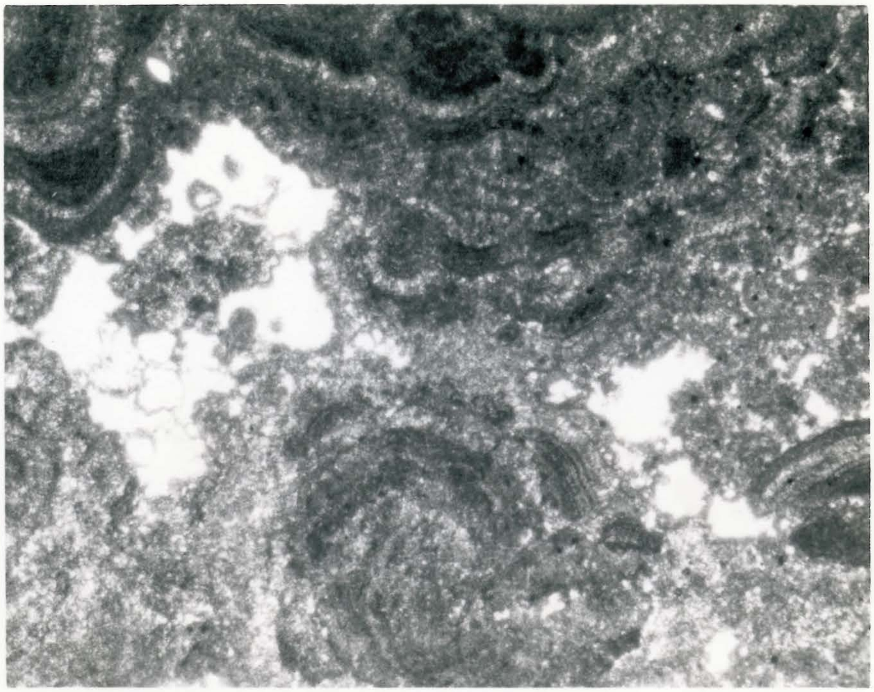

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Figure 29. Photomicrograph of vug filling by sparry calcite. Section I, Flagstaff Limestone.

Summary and Conclusions

The study of oncolites in modern fluvial and lacustrine environments has contributed much to the understanding of paleoecologic and paleoenvironmental settings. Results noted are: (1) The presence of sparitized nodules encapsulated by a laminated micritic coating is highly suggestive of algal binding of carbonate grains. SEM photomicrographs lend strong evidence supporting algal participation. (2) Studies of the paleocurrent and long axis orientation relationships are extremely helpful for understanding the depositional setting and comprehending the role of wave and current action in oncolite formation. In the zone of wave action on the beach the cross-beds will be down the beach front, but pebbles rolling on the beach and in shallow water would be perpendicular to the beach slope. (3) The distance the sediments were transported was relatively short as suggested by the presence of a large amount of lithic fragments and poorly sorted texture. A possible source for these sediments is the Sanpete Valley anticline. Further studies of oncolites and oncolitic environments are necessary for a more comprehensive picture of the role they can play in interpreting paleoecology and paleoenvironmental settings of fluvial and lacustrine units.

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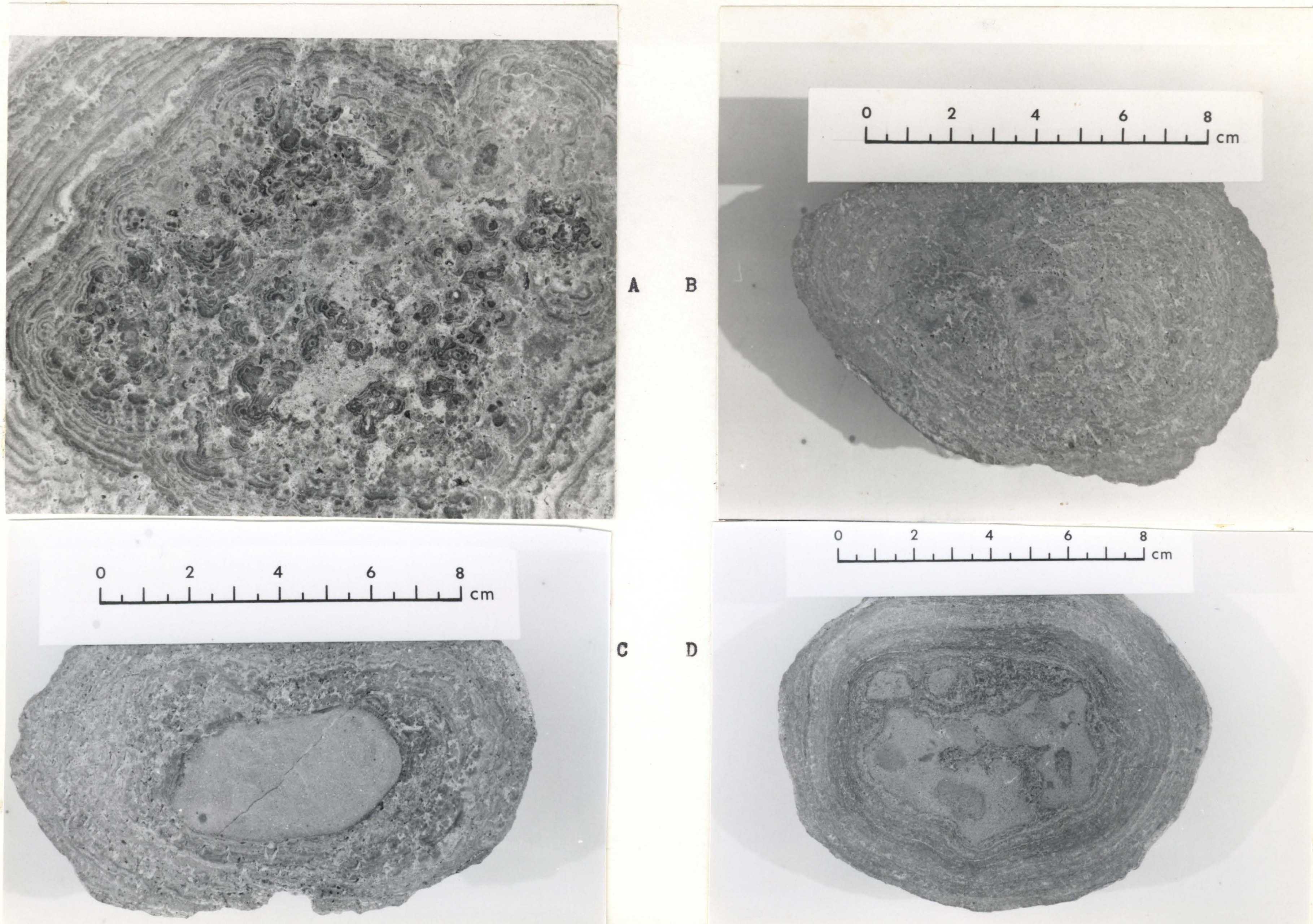
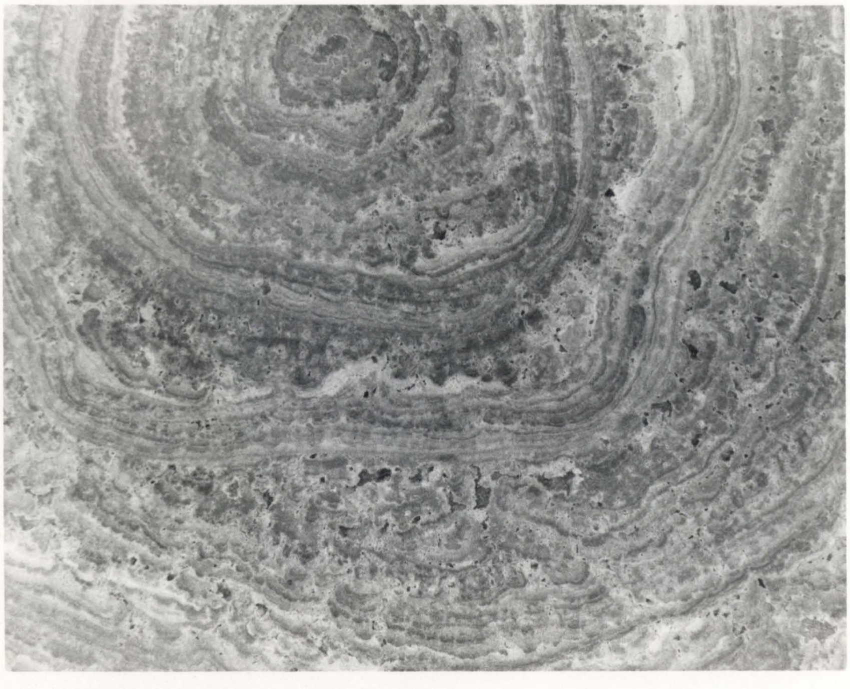


Appendix 1: North Horn Oncolites. A. Close-up of polished center composed possibly of calcite replaced algal coated charaphyte stems. B. Polished section exhibiting pustular structure. C. Polished section containing quartzite center. D. Polished section showing center composed of algal encased sand bodies. Calcite replacement of algal structures and some calcite filling of interstitial spaces also was noted.

Flagstaff Oncolite

A. Polished section showing distinct light and dark alternating laminae.



B. Close-up showing sparry calcite filling of vugs.

Apendix 2

Paleocurrent Readings

Section I - Flagstaff Limestone

N 40 E	N 83 W	S 10 E	N 55 W	S 85 W
N 75 W	N 80 W	N 85 W	N 40 E	N 50 W
S 60 W	N 90 W	N 20 W	N 20 W	N 20 E
N 48 W	N60 E	N 35 W	N 15 W	N 20 W
N 28 w	N 90 W	N 70 W	N 55 E	N 10 W
N 49 W	N 35 E	North	N 12 E	N 30 W
N 59 W	N 25 W	N 45 E	N 20 W	N 75 E

Section I - North Horn Formation

N 54 W	S 71 W	N 57 W	N 46 W	S 62 W
N 65 W	N 48 W	N 18 E	N 68 W	S 64 W
N 56 W	N 51 W	N 46 E	N 84 W	N 69 W
N 83 W	N 29 W	S 12 W	N 70 W	
N 69 W	N 25 W	S 47 W	S 60 W	
N 84 W	N 57 W	N 74 W	N 53 W	
N 55 W	N 51 W	N 54 W	N 65 W	

Section 2 - North Horn Formation

N 72 W	N 10 E	N 23 W	N 57 W	N 70 W
N 40 W	N 76 W	North	N 61 W	N 35 W
N 35 W	N 15 W	N 8 E	N 64 W	N 70 W
N 53 W	N 64 W	N 50 W	N 50 W	N 73 W
N 41 W	N 85 W	N 46 W	N 45 E	N 80 W
N 54 W	N 71 W	S 62 W	N 15 E	N 78 W
N 37 W	N 40 W	N 64 W	N 52 E	S 70 W
N 3 E	N 25 W	N 29 W	N 47 E	

Appendix 3

Axis of Elongation

Section I - Flagstaff Limestone

N 38 E	N 41 E	N 10 W	N 50 E	North
N 53 E	N 48 E	N 10 E	N 53 E	N 50 E
N 88 E	N 43 E	N 65 E	N 55 E	N 70 W
N 35 E	N 70 W	N 60 W	N 63 E	N 70 W
N 46 E	E - W	N 70 W	N 68 E	N 55 E
N 25 E	N 70 W	N 75 W	N 30 E	N 48 E
N 60 W	N 10 E	N 55 E	N 50 E	N 48 E
N 85 W	N 38 E	N 17 E	N 60 W	N 20 E
N 5 W	N 80 E	N 38 E	N 40 W	N 48 W
N 80 E	N 85 E	N 50 W	N 20 W	N 65 E
N 70 E	N 25 E	E - W	N 50 E	N 22 W
N 50 E	N 75 E	E - W	N 20 E	N 10 E
N 40 E	N 30 W	N 70 W	N 42 E	N 31 E
N 15 E	N 23 W	N 70 E	N 30 E	N 43 W
N 44 E	N 35 W	N 50 E	N 28 E	N 28 W
N 88 E	N 20 W	N 35 E	N 3 E	N 50 E
N 60 E	N 30 W	N 33 E	N 60 E	E - W
N 43 E	North	N 53 E	N 68 E	N 35 E
N 5 E	N 40 W	N 15 W	North	N 22 W
N 43 E	North	N 20 W	N 50 E	N 50 E

Section I - North Horn Formation

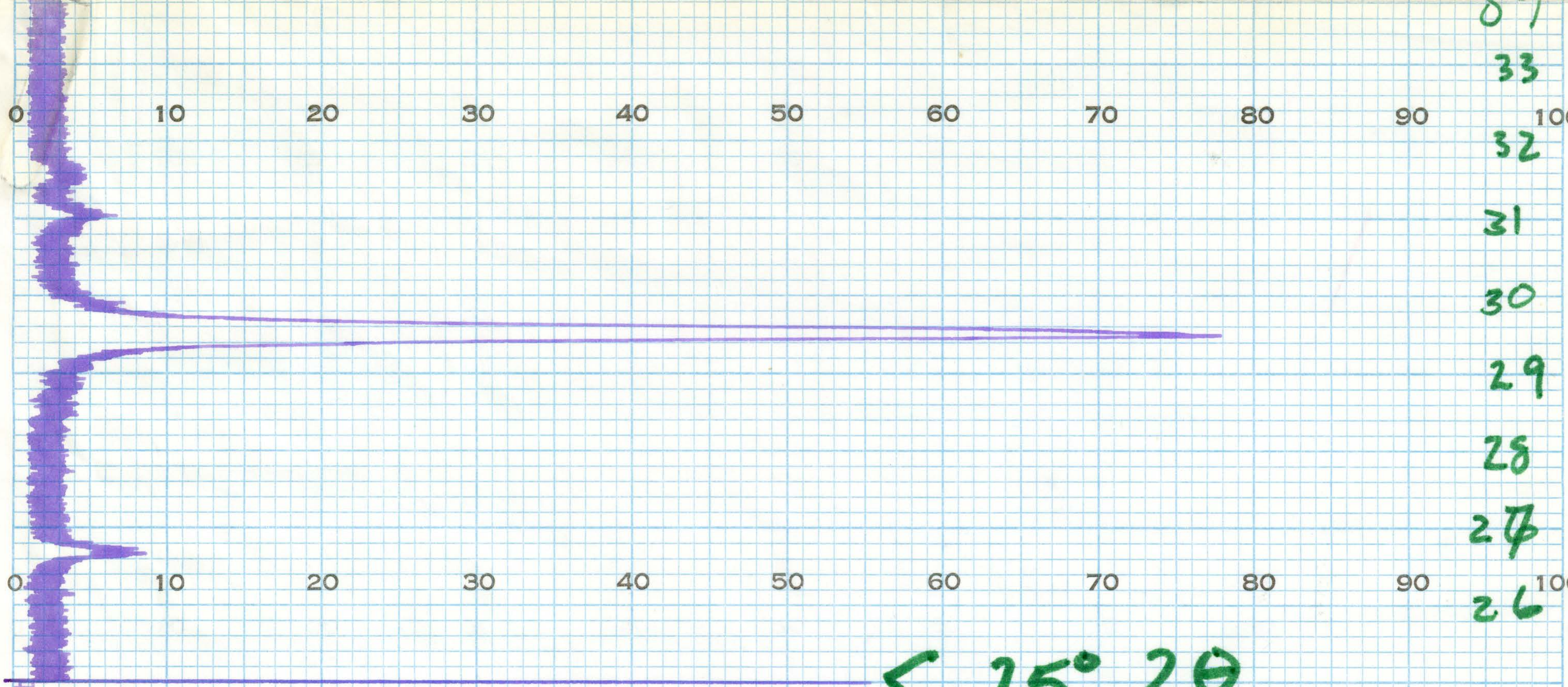
S 75 W	N 70 E	N 20 W	N 3 E	N 38 E
N 25 E	N 33 W	N 18 E	N 10 E	N 42 E
S 15 E	N 80 E	N 24 E	N 28 E	N 50 E
E - W	N 26 E	N 39 E	N 65 E	N 10 E
N 19 E	N 40 E	N 36 E	N 60 E	N 60 E
N 16 E	N 14 W	N 46 W	N 88 W	N 16 E
N 38 E	N 10 E	N 44 E	N 87 E	N 80 W
N 45 E	N 50 E	N 85 W	N 63 W	N 50 E
N 56 E	N 70 W	N 53 E	N 88 E	N 79 W
N 21 E	N 28 E	N 51 E	N 42 E	N 21 E

Section I - North Horn Formation (Continued)

N 89 W	N 44 E	N 62 E	N 66 E	N 6 E
N 45 E	N 34 E	N 31 E	N 55 W	N 15 W
N 46 E	N 26 E	N 51 E	N 40 E	N 4 E
N 13 W	N 16 E	N 24 E	N 54 E	N 75 E
N 21 E	N 20 W	E - W	N 87 W	N 10 E
N 46 E	E - W	N 6 W	N 68 W	N 9 E
N 64 E	E - W	North	N 66 W	N 11 W
N 19 E	N 52 E	N 2 E	N 85 E	N 5 W
N 24 W	N 47 E	N 54 E	N 56 E	N 48 W
North	N 4 E	N 85 W	N 3 W	N 58 E

Section 2 - North Horn Formation

N 33 E	N 22 E	N 50 E	N 70 E	N 8 W
N 6 E	N 6 E	N 54 E	N 40 W	N 18 W
N 18 E	N 45 E	N 75 W	N 76 W	N 5 E
N 16 E	N 30 E	N 56 E	N 65 E	E - W
N 55 E	N 48 E	N 74 E	N 52 W	N 68 E
N 45 E	N 50 E	N 56 E	N 21 E	N 23 E
N 29 W	N 60 E	N 64 E	N 47 W	N 12 E
North	N 41 E	N 63 E	N 2 W	N 20 E
E - W	N 44 E	N 44 E	N 6 E	N 55 E
N 70 W	N 36 E	N 74 E	N 4 E	N 28 E
N 62 E	N 28 E	N 4 W	N 42 E	North
N 45 E	N 72 E	N 75 E	N 40 E	N 15 E
N 70 E	N 26 E	N 42 W	N 28 E	E - W
North	N 40 W	E - W	N 78 E	N 6 E
N 44 E	N 22 W	N 83 E	N 60 E	N 40 E
N 80 W	N 20 E	N 77 E	N 50 W	N 4 E
N 17 W	N 48 E	N 72 W	N 8 E	N 25 E
N 26 W	N 8 W	E - W	North	N 13 E
N 55 W	N 74 E	N 75 E	N 30 E	N 60 E
N 8 E	N 42 W	N 69 E	N 27 E	N 36 E



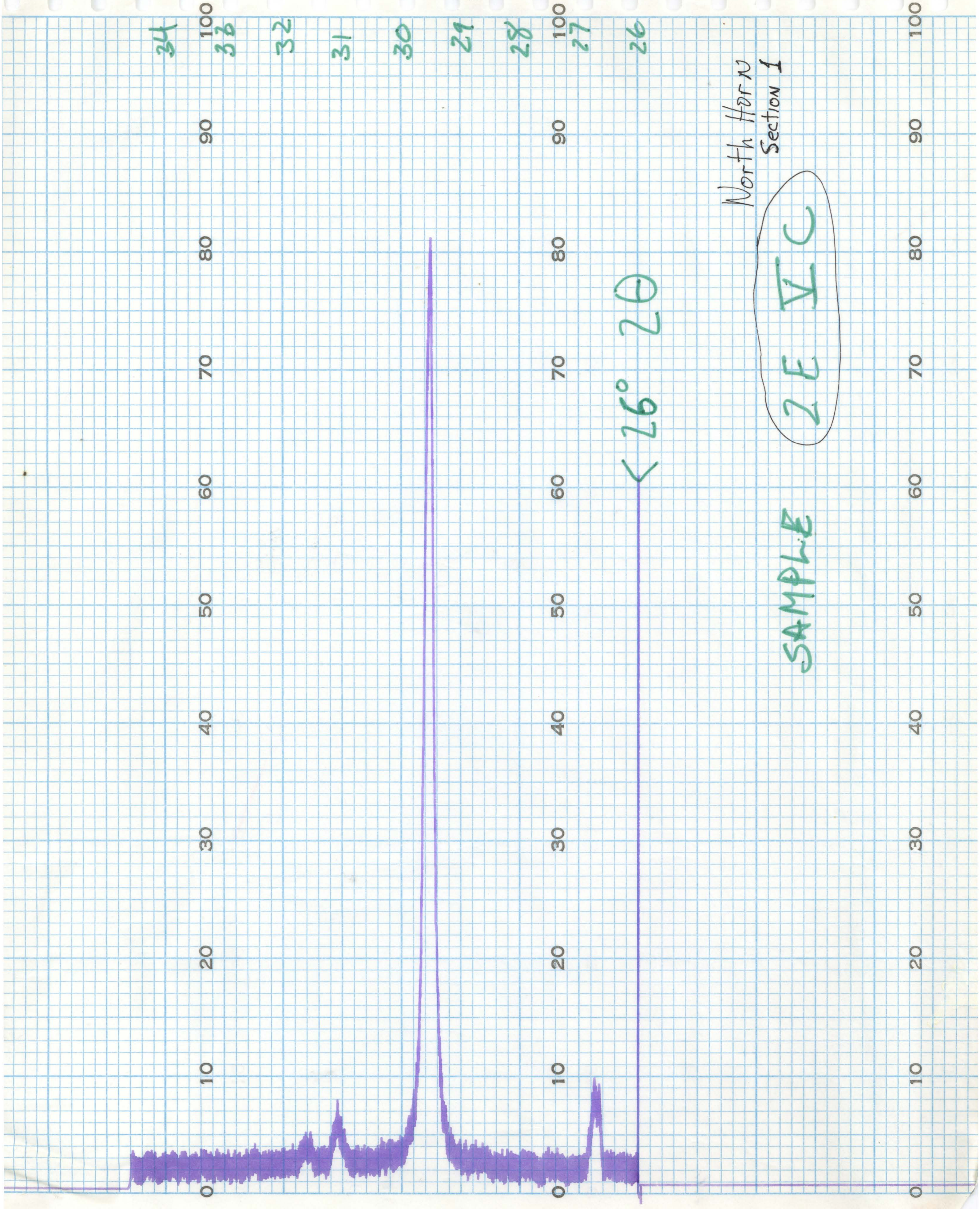
< 25° 2θ

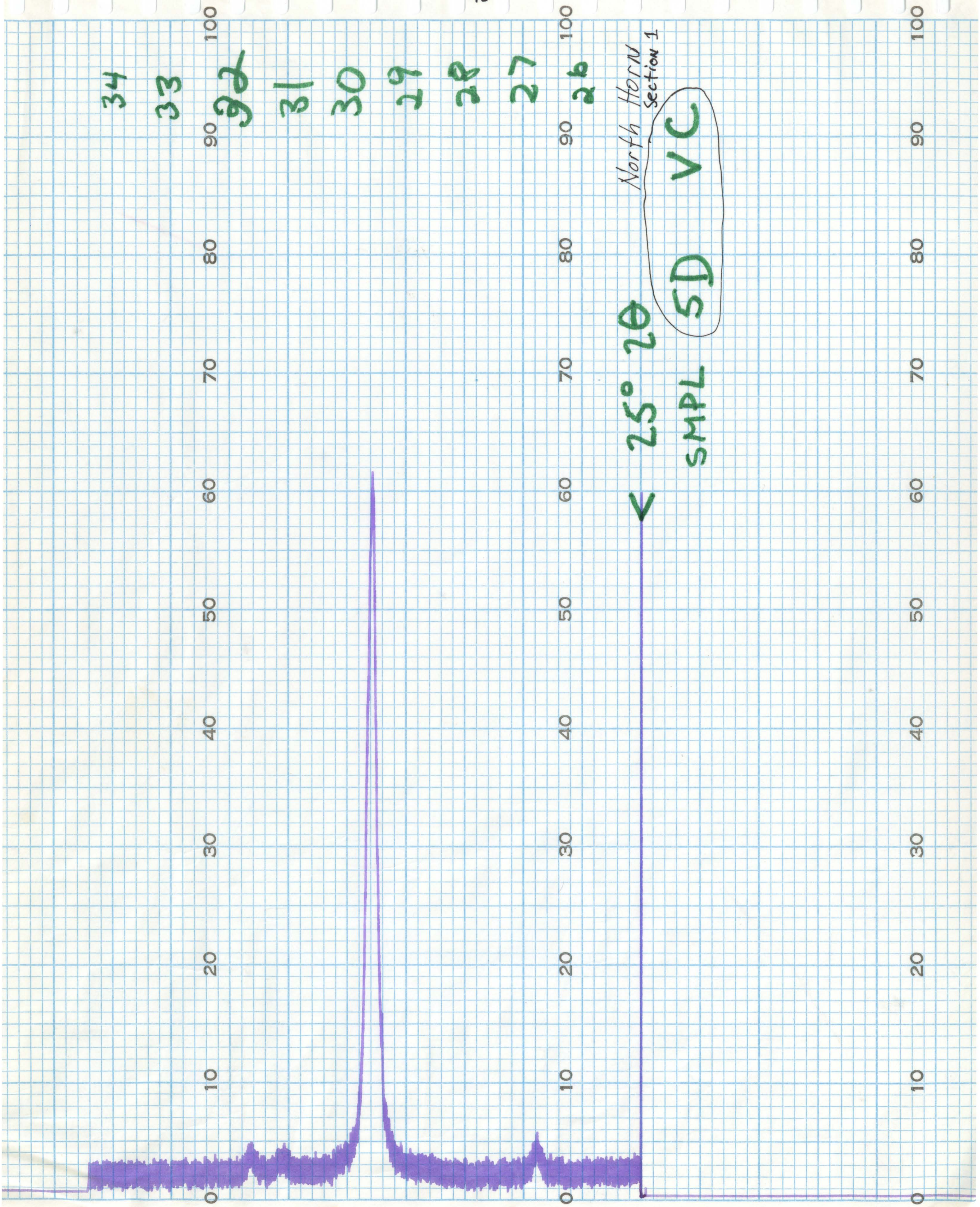
Flagstaff
Section I

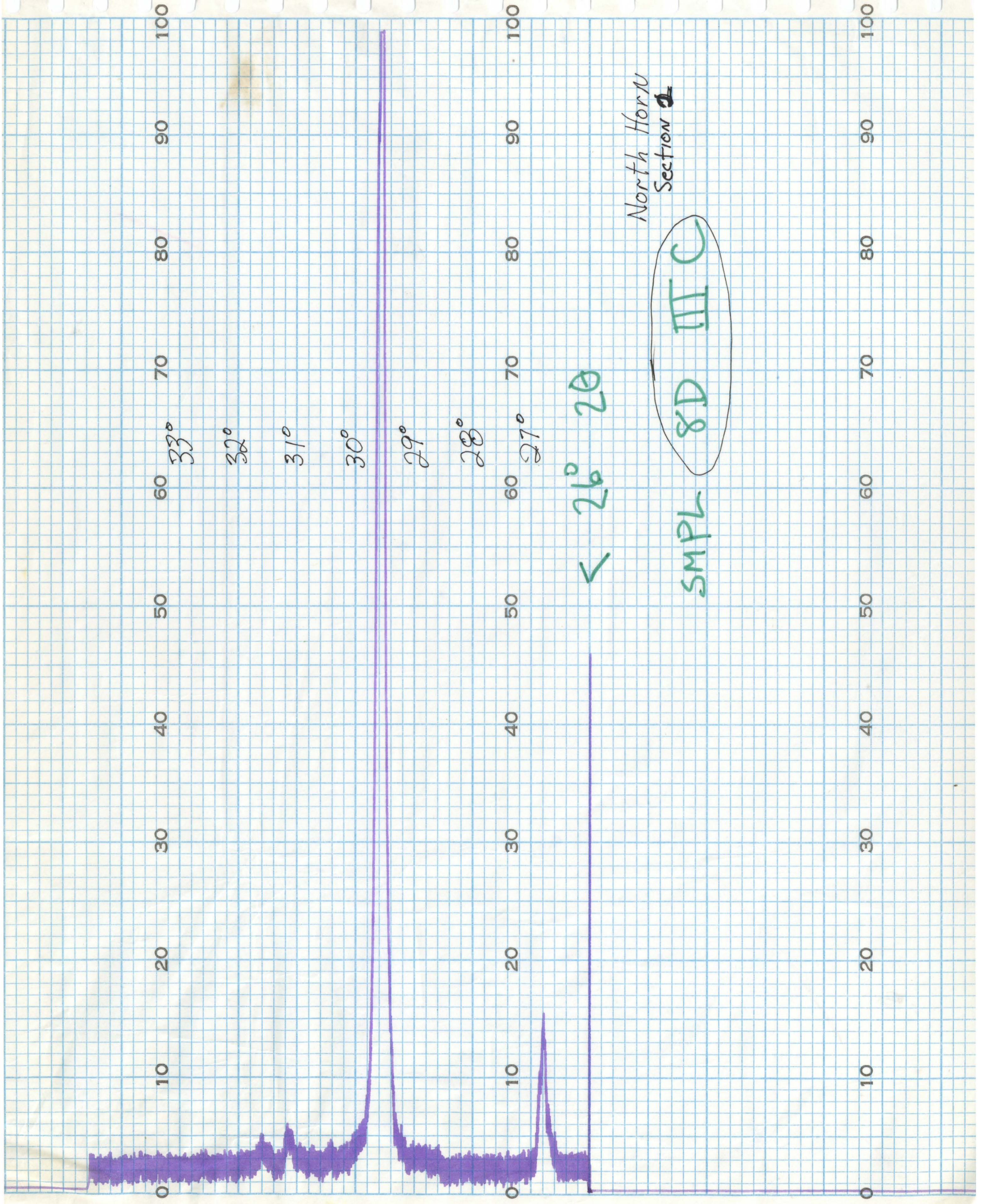
SMPL 6B 12C

Cu Kα
Ni Filter
Scan speed 1° 2θ/min
Chart speed 30"/hr
1° scatter slits
1° receiving slits

Detector 1550 V
Target 35 kV
20 mA
scale 16
Multiplier 1
Time const. 1


34
33
32
31
30
29
28
27
26
< 26° 2Θ
North Horn
Section 1
2 E V C
SAMPLE
0
10
20
30
40
50
60
70
80
90
100


North Horn
Section 1
VC
5D
25° 2θ
SMPL
34
33
32
31
30
29
28
27
26


North Horn
Section
SMPL 8D III C
< 26° 2θ
33°
32°
31°
30°
29°
28°
27°
100
90
80
70
60
50
40
30
20
10
0